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THE SARGASSO SEA.

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THERE seems to have always been some fascination about the Sargasso Sea, inducing people who had practically no knowledge of it to publish extensively in regard to it. The character of such publications ranges from Janvier's amusing and quite Munchausenish story¹ to Otto Kuntze's less interesting but no more trustworthy work². It has been described by older authors as a vast meadow, with an area larger than the whole of Germany, the dense vegetation seriously impeding the progress of vessels. "Crescit in omnibus fere rupibus aqua marina apertis circa Jamaicam, aliisque Americae pluribus, unde a fluctibus abruptum, magnamque partem maris Americani borealis implet, ut pratum viride diceret spectator remotus."³ Kuntze and others consider it as consisting only of fragments of algae, torn from the shores of the West Indies, decaying and soon sinking. Most recent authors have held a more or less modified form of the latter theory, but Sauvageau⁴ has shown its impossibility, and Børgesen⁵ has brought together the more important data of previous authors, adding his own observations in several times crossing the Sargasso Sea, and reaching the conclusion that the plant in question, whatever its remote

¹ T. A. Janvier, *In the Sargasso Sea*. New York. 1898.

² Otto Kuntze, *Revision von Sargassum und das sogenannte Sargasso-Meer*. Engler's Bot. Jahrb., Vol. I, 1881.

³ Linnaeus, *Hortus Cliffortianus*, p. 478, 1737.

⁴ C. Sauvageau, *Le Sargassum bacciferum, la mer des Sargasse et l'Océanographie*. Comptes Rendus de la Soc. de Biologie, Vol. LXII, p. 1082, 1907.

⁵ F. Børgesen, *The species of Sargassum found along the shores of the Danish West Indies, with remarks upon the floating forms of the Sargasso Sea*. Mindeskrift for Japetus Steenstrup, no. 32, 1914.

origin, is now a pelagic perennial, of continuous active growth, forming abundantly vesicles, leaves and branches, but as far as observed, no fructification; the lower part continually decaying and wearing away. Whenever this decay reaches the base of a branch, or a fork of the main axis, we have two individuals, in a loose sense of the word, in place of one. All this was set forth over sixty years ago by Harvey,¹ but his clear and full statement in this work, which is the basis of North American phycology, has been ignored by following writers, who substituted their own or others' guesses for Harvey's personal observations. Börgesen copies Harvey's remarks in full.

The floating species has passed under the name *Sargassum bacciferum* (Turner) Agardh² although both Turner and Agardh give as a synonym *Fucus natans* Linnaeus, Sp. Pl., Vol. II, p. 1160, 1753; Börgesen restores the correct form, *S. natans*; but as the earliest author he could find for this binomial was Robert Brown, Proc. Linn. Soc., Vol. II, p. 77, 1855, and Brown did not apply it to the present species, he uses the form *S. natans* (L.) only. M. A. Howe in a review of Börgesen's paper, Torrey, Vol. XV, p. 49, 1915, calls attention to the use of the binomial by J. Meyen in 1838³ which gives as the correct form, *S. natans* (L.) J. Meyen.

Börgesen has examined the Linnaean type, and it is the common narrow-leaved form of the Sargasso Sea; but among the floating vegetation he finds beside this, although in less quantity, another form, which in the paper referred to he calls *S. Hystrix* J. Ag., var. *fluitans* Börge., but in a later paper⁴ raises to specific rank as *S. fluitans* Börge.

That the floating *Sargassum* must at some time have been derived from an attached plant is generally assumed, but apart from Börgesen's supposition that his new form was a variety of the attached and fruiting *S. Hystrix*, no one has published any serious attempt to determine the origin.

The coast of southern New England comes within the range of *Sargassum*, an attached species, *S. Filipendula* Ag., being rather common here. This is the *S. vulgare* of Harvey, Nereis Bor.-Am., part 1,

¹ W. H. Harvey, Nereis Boreali-Americana, part 1, p. 54, 1852.

² C. Agardh, Sp. Alg., Vol. I, p. 6, 1821; *Fucus bacciferus* Turner, Hist. Fuc., Vol. I, p. 103, Pl. XLVII, 1808.

³ J. Meyen, Jahresbericht über die Resultate der Arbeiten in Felde der physiologischer Botanik v. d. Jahre 1837. Wiegmann's Archiv für Naturgeschichte, Vierter Jahrgang, Zweiter Band, Berlin, 1838.

⁴ F. Börgesen, The marine algae of the Danish West Indies, part 2, Phaeophyceae. Dansk. Botanisk Arkiv, Vol. II, p. 157, 1914.

p. 59, as to New England localities; Hervey, *Sea Mosses*, p. 74; Farlow, *Marine algae of New England*, p. 103, and of various papers and lists, but not *S. vulgare* Agardh, as is pointed out by J. G. Agardh, *Sp. Sarg. Austral.*, p. 120, 1889. *S. natans* is occasionally washed ashore from Vineyard Sound south; it follows the course of the Gulf Stream, and in times of strong, long-continued easterly winds, considerable quantities may be found from Gay Head to Nantucket Shoals. I have picked up a much battered fragment at Menauhant, in the eastern part of Falmouth, Massachusetts, and know of no record of its coming ashore farther north. *S. fluitans* is occasionally found with it. J. G. Agardh, *Sp. Sarg. Austral.*, p. 106, writes, "radice instructam et fructiferam ad oras Americae foederatae lectam habeo, in rupibus extra New Foundland." I agree with Börgesen, *Sp. Sarg.*, p. 12, "That the plant should have been found 'radice instructam' i. e. attached, near Newfoundland seems so unlikely that I deem it unworthy of consideration." Incidentally it is an interesting question geographically what part of the United States is on the rocks beyond Newfoundland. I have a specimen marked "In oceano prope Terre-Neuve fluitantem legit Lesquereux." A change of labels between this or another specimen of the same origin, and some attached plant, may have been the cause of Agardh's statement. Durant¹ notes finding it in New York Harbor, and includes it among the specimens accompanying his book. These specimens are of the typical form. It drifts ashore on the New Jersey coast,² and though there are practically no records of algae from Atlantic City, New Jersey to Charleston, South Carolina,³ in all probability it grows more frequent as one goes south.

Perhaps the best place for the study of the pelagic *Sargassum* is the Bermuda Islands. On the voyage from New York one begins to see the floating patches and strips of the alga within 24 hours after leaving, and they continue in sight the rest of the voyage. They are everywhere in sight as one sails or rows about the islands, and windrows of the *Sargassum* may be found about high water mark on lee shores, like the windrows of *Laminaria* on the rocky shores of New England. The

¹ C. F. Durant, *Algae and Corallines of the Bay and Harbor of New York*. New York, 1850. For a full notice of this curious and long lost work, see Arthur Hollick. *Proc. Staten Island Asso. A. & S.*, Vol. V, p. 85, 1915.

² I. C. Martindale, *Marine algae of the New Jersey Coast*, *Mem. Torr. Bot. Club*, Vol. I, p. 99, 1889.

³ A list of the algae of Beaufort, North Carolina has been compiled by Dr. W. D. Hoyt, and will soon appear as a publication of the Bureau of Fisheries, Department of Commerce.

Sargassum is used in Bermuda for fertilizer as is *Laminaria* with us, and it is an important factor in agriculture. To one who has seen it only as scattered floating strips, the amount thrown ashore during a blow is astonishing. At the head of the narrow Inlet, near Flatts Village, I have known more than a hundred cartloads to be obtained from the mass brought in by one northwesterly gale. In my visits to Bermuda, April–May, 1912, and July–Sept., 1913, I was busy with other algae, and noticed only incidentally the floating forms; but one of the principal objects of my visit in Nov.–Dec., 1915, was to observe these floating forms. For this I had good facilities, thanks to Prof. E. L. Mark, Director, and Dr. W. J. Crozier, Resident Naturalist, of the Bermuda Biological Station. All facilities of the Station at Agar's Island were at my disposal. I lived at the island, collecting at its shores, and by excursions in motor boats in various directions.

As already noted, the floating material is sometimes in scattered irregular patches, but when there is any wind, it forms narrow strips, in the line of the direction of the wind. This is noted by Börgesen, Sp. Sarg., p. 12. "The Gulfweed is nearly always found in long narrow rows arranged in the direction of the wind, and at a right angle to the moving of the sea." The last phrase is rather ambiguous, possibly misleading. The strips are at right angles to the crests of the waves, but in the line of their motion, which is of course the same as that of the wind. He says further, "The Sargasso floats frequently so near the surface that tips of the leaves become emerged when moved by the sea." This is an exact description of the appearance in rough or even slightly moving water. In calm water one sees that a frond, as a whole, is of a slightly less specific gravity than the water; the stem lies just below the surface, and as the stiff leaves are radially arranged, those on one side project above the surface, from one to three cm., thickly set over the whole patch, much like the peduncles of some flowering plant, *Elodea* or *Potamogeton*. It is only in smooth water, and when the observer is nearly on a level with the water, that this is noticeable, but here it is quite striking. The color is quite light, yellowish olive; distinctly lighter than that of the attached species found in Bermuda. It is darker in the lower part of the individual. There are several attached species at Bermuda, *S. lendigerum* (L.) Agardh being the commonest, and found on exposed shores all around the islands. The same storms that bring ashore the pelagic forms, tear off fragments or even whole plants of the attached forms, which may

be found scattered through the mass, on or near the shore, but there is no danger of a careful observer making any mistake. The plants of *S. lendigerum* and the other attached species are darker in color, never project above the surface, and soon decay.

S. fluitans I found scattered among *S. natans* all about Bermuda; at a rough estimate about five per cent of the former, ninety-five per cent of the latter. They are quite distinct, and in the large quantity of both species I examined, I found no intermediate forms. Indeed I found that when I had shown a specimen of each to our boatman, who knew nothing whatever of algae, he was able to distinguish in the floating mass the less common *S. fluitans*, and bring in with his boat-hook as much as I wanted, without once making a mistake. *S. natans* and *S. fluitans*, collected together in lat. 25.58 north, long. 73.39 west, were distributed in Collins, Holden & Setchell, Phyc. Bor.-Am., the former under No. 833 as *S. bacciferum* forma *angustum* Collins, the latter under No. 832b as *S. bacciferum*. It is unfortunate that of the two forms then passing under the name of *S. bacciferum* the one corresponding to *S. fluitans* should have been taken as representing the type, and a form name given to the other, which we now know agrees with the Linnaean type.¹

It is not impossible that *S. fluitans* has been derived from *S. Hystrix*, but if so, it must be a somewhat remote derivation, and the modifications have been sufficient to justify its rank as a distinct species. The derivation of *S. natans* is probably still more remote, the differentiation greater. Among the species known to me, the one that most resembles *S. natans* is one found at Bermuda resembling *S. linifolium* (Turn.) J. Ag., of the Mediterranean and the Adriatic. In the Bermuda plants so referred the leaves are very long and slender, as in *S. natans*, and the vesicles are not unlike. That this plant has been reported, as far as I know, from no other American station, is not of much importance if we consider the pelagic form to have arisen long ago, and not now to receive any accessions from attached plants. That no floating form occurs in the Mediterranean, where *S. linifolium* is common, may suggest that the Bermuda plant, though resembling the Mediterranean species, is distinct; indeed I am still in doubt after examining a large number of specimens of the former, and comparing

¹ By a misprint in the label of No. 833, the latitude is given 55.58. It is however, stated that the material was collected at the same time and place as that of No. 832, which has the correct figures of latitude, 25.58.

them with authentic specimens of the latter. The Bermuda plant grows always in sheltered places, and is rarely found floating even after severe storms; *S. lendigerum*, a very different species, inhabits exposed shores, and as already noted, is frequently mixed with *S. natans* after storms. In my last trip to Bermuda I collected a considerable quantity of each of the four species spoken of above, and attempted to rough-dry it for later study and mounting, but owing to unfavorable weather during the last few days of my stay, I had to pack up quite an amount still moist. It was more than ten days before it was unpacked, and I found that while the three other species were in good condition, all of the *linifolium* form was decayed and worthless. How much weight should be given to these considerations as against the origin of *S. natans* from this species it is hard to say; it may be that the pelagic condition is sufficient to account for the differences.

In considering the question of the antiquity of this pelagic form, it is interesting to note that at present a considerable fauna is associated with the Sargasso Sea, quite distinct from that found on attached *Sargassum*. I have seen statements that at least fifty species of animals have been recorded as characteristic of it, many of them seldom found elsewhere. This association is so well known to the collectors at the Wood's Hole Biological Laboratory, that when the gulfweed is reported as coming near land, they go out to obtain from it a number of species that they keep in stock, but never find otherwise. Among these are the attached mollusk, *Litiopa bombix*, some free amphipods, two crabs, *Planes minutus* and *Partunus Sayi*, and most interesting of all, the fish *Pterophryne histrio*. It seems to me that the specialization of this fish to its habitat in the *Sargassum* is a strong evidence of the antiquity of the latter in its present condition. The markings on the fish closely simulate the leaves of the plant, and it has several outgrowths, exactly like battered and bristly stalks of the plant, and except for protection by resemblance, of no use that we can see to the fish. It is practically impossible to distinguish the fish from the floating alga in which it lives. "The marvellous and undoubtedly protective coloration and configuration of this fish render it one of the most striking objects which appear on the coast."¹

The animals mentioned are displayed in the public collections of the Boston Society of Natural History as "Sargassum Crabs" etc. There

¹ F. B. Sumner in A biological survey of the waters of Woods Hole and vicinity. Bull. Bureau Fisheries, Vol. XXXI, part 2, p. 774, 1913.

is a colored plate of the *Pterophryne* in G. B. Shattuck, The Bahama Islands, Pl. LV, 1905. In this the fish is painted in colors brighter than in nature, the gulfweed in duller; but even so, the mimicry is striking.

Is there reason to suppose that the Sargasso Sea contains any other species of algae? I think that there is evidence that *Ascophyllum nodosum* (L.) Le Jolis, if not actually adapted to a pelagic life, shows a tendency towards it. While never found attached at Bermuda, it is occasionally found among floating *Sargassum*, indeed one is almost sure to find it by going carefully over any large mass of the latter. It is always without basal disk, and the lower part is in the same worn condition shown by the *Sargassum*. In one instance the lower end of the frond showed a cup-shaped cavity, caused by internal decay, and in this were three individuals of the barnacle, *Lepas anatifera*, an organism never recorded on *Ascophyllum* under normal conditions, and of a size indicating an age of not less than two weeks. This indicates only the shortest length possible for its floating condition. It is a common shore plant from the arctic regions to New Jersey on the American coast, to the Bay of Biscay on the European. It seems less likely that it could come from the former, crossing the rapid current of the gulfstream, than that it should come from Europe, from which a westerly current passes just south of Bermuda. As to its occurrence with *Sargassum* elsewhere, Bouvier¹ says, "Ça et là, parmi les Sargasses, on rencontre quelques fragments de *Fucus nodosus*, arrachés certainement aux rivages des Canaries, de Madère ou des Açores." To be sure, Sauvageau, *Sargassum bacciferum*, p. 1083, points out that the *Fucus* (*Ascophyllum*) has never been reported growing at the Canaries, Madeira or the Azores; but Bouvier's erroneous assumption does not invalidate his record of the occurrence of the plant. Börgesen writes me "Professor Gran has most kindly communicated me that *Ascophyllum* was found in the northern part of the Sargasso Sea, and rather abundant." It seems probable then that *Ascophyllum nodosum* occurs, though in quite small quantity relatively, throughout the Sargasso Sea. But in one important respect it differs from the species of *Sargassum*; it is frequently found in fruit, sometimes luxuriantly. If, as is now generally believed, fructification in algae is a response to changed conditions, usually condi-

¹ Bouvier, Bull. del' Institut Oceanographique, 1907, No. 93, p. 35.

tions unfavorable to vegetative growth, its absence in the pelagic *Sargassum* is probably due to the uniformity of conditions and steady vegetative growth; the *Ascophyllum* has at any rate not reached that state.

The only other plant to be considered in this connection is a *Cystoseira* resembling *C. crinita* Bory, a number of specimens of which were found in a lot of *S. natans*, collected in the North Atlantic by Professor F. H. Storer, in August, 1854, on a voyage in a clipper ship from Canton to New York.¹ The *Cystoseiras* are specially characteristic of the Mediterranean, but extend on the Atlantic both north and south of the Straits of Gibraltar. Sauvageau,² gives 33 species as occurring within this range, and considers the floating plant, while nearest to *C. crinata*, not exactly identical. The only American species of the genus is *C. Myrica* Bory, a very different plant.

In conclusion:—The predominant species of the Sargasso Sea is *S. natans* (L.) J. Meyen; through long pelagic existence so differentiated from its original attached ancestor that the latter cannot now be identified; of active vegetative growth but propagating only by fragmentation, having associated with it a much specialized fauna. The *Sargassum* exists not as a continuous mass, but as scattered patches through an area in the North Atlantic bounded by the Gulf Stream, and its subsidiaries reaching the coast of Europe, thence south and again west to the point of origin in the Gulf of Mexico; fragments may be driven by high winds to the shores of New England and Northern Europe. *S. fluitans* Börge. accompanies it, but in less quantity, less differentiated, probably more recently, from its attached ancestor, which may be *S. Hystrix* J. Ag. Of equal distribution but in relatively minute proportion, *Ascophyllum nodosum* (L.) Le Jolis is practically undifferentiated from the attached plant, but though floating and fruiting freely for weeks, probably for months, cannot be considered persistent in the pelagic condition. Finally there is a sterile *Cystoseira*, resembling *C. crinita* Bory, found once only, its status therefore uncertain.

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¹ For details of this collection, as also for many interesting remarks on pelagic *Sargassum*, see W. G. Farlow, The vegetation of the Sargasso Sea. Proc. Amer. Phil. Soc., Vol. LIII, p. 257, 1914.

² C. Sauvageau, À propos des *Cystoseira* de Banyuls et de Guéthary. Bull. Sta. Biol. Arcaçon, 14e année, 1912.